学 位 論 文 要 旨

Identification of the quantitative trait loci for breaking and bending types lodging resistance in rice

（イネにおける挫折型およびたわみ型倒伏抵抗性に関与する量的形質遺伝子座の特定）

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Lodging is the phenomenon that crop stem changes from natural upright state to permanent dislocation, and it is one of the major constraints for achieving high yield of small grain cereals including rice. Lodging can be classified into stem lodging and root lodging, and stem lodging of breaking and bending types is a predominant form in the transplanting rice cultivation. To develop new rice cultivars with increased plant biomass and grain yield, lodging resistance is an essential trait for this strategy. The new approach can be adopted for improving stem lodging resistance by enhancing culm strength. The resistance to breaking type lodging is attributed to the bending moment of basal culm (M), which is composed of section modulus (SM) and bending stress (BS). The resistance to the bending type lodging in rice is attributed to flexural rigidity (FR) of the stem, which is composed of the secondary moment of inertia (SMI) and Young's modulus (YM). Cell wall components such as cellulose, hemicellulose and lignin and starch also play a significant role in physical strength of culm, and thus affect the resistance to stem lodging in rice. The improved lodging resistant cultivar, Leaf Star has the highest M because of its large SM, which is an indicator of culm thickness and higher BS, which is an indicator of culm stiffness. Thus, Leaf Star has a superior resistance to lodging owing to the combination of culm thickness and culm stiffness.

To improve the lodging resistance of new long-culm cultivars efficiently, it is necessary to identify QTLs for these traits. In this study, the QTL analysis was performed for these traits associated with culm strength, using 94 recombinant inbred lines (RILs) derived from a cross between Leaf Star and Koshihikari.

Based on QTL analyses using RILs, a total of 12 QTLs on chromosomes 1, 2, 3, 5, 10 and 11 were detected for breaking-type lodging resistance in F_7 and F_8 RILs. Furthermore, 12 QTLs affecting bending-type lodging resistance were also detected in F_7 and F_8 on Chrs. 2, 3, 5, 10 and 11. QTLs for SM and SMI on Chrs. 2 and 3 overlapped with QTLs associated with *Strong Culm 3 (SCM3)* on Chr. 3 and *SCM4* on Chr. 2 identified from Chugoku 117 and Koshihikari. QTLs for starch and cell wall components such as cellulose and hemicellulose were detected on Chr. 5 with Leaf Star allele's contributions. The QTL for starch accumulation in culms was also detected at the same regions on Chr.5 with Leaf Star allele contribution in two years.

Two reciprocal chromosome substitution lines (SLs), TULK-6 and TULK-75 with Koshihikari or Leaf Star segment on chr.5 in Koshihikari or Leaf Star genetic background were developed to evaluate the effects of Chr. 5 segments on starch and cell wall components, and were used to compared starch and hemicellulose contents and densities with their recurrent parents. TULK-6 showed significantly higher starch content and density and hemicellulose density than Koshihikari due to Leaf Star alleles on Chr. 5, while TULK-75 showed significantly lower starch content and density, and significantly lower hemicellulose density in both years compared to those in Leaf Star due to carrying Koshihikari alleles on Chr. 5. These results indicated that the chromosome segments of Leaf Star on Chr. 5 affected the accumulations of starch and cell wall components such as cellulose and hemicellulose.

Finally, to narrow down the candidate regions for QTLs on Chr.5, the substitution lines for TULK-6 with Leaf Star segments in the Koshihikari genetic background were developed. The QTLs for starch and cell wall components were mapped at the short arm and central regions on Chr. 5.

This study suggests that the new identified QTLs for culm thickness and culm stiffness contribute to improve the stem lodging resistance in rice cultivars.